Sediment basins

This fact sheet is one of a series which provides advice to extension officers and land managers on the use of sediment basins to improve run-off water quality, specific to coastal agriculture in the wet/dry tropics region between central and Far North Queensland.

Sediment basins

Sediment basins are run-off treatment systems that promote the settling of sediments through the reduction of flow velocities (speeds) and their temporary detention. They target the removal of coarse and medium sized sediments from farm run-off.

Key elements of the basins include inlet and outlet structures, settling pond and high flow and overflow structures.

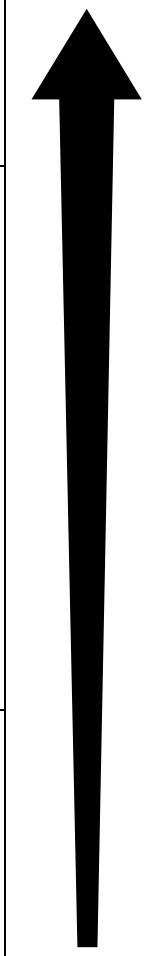
They can take various forms and can be used as permanent systems or temporary measures to control sediment loss during tillage and harvesting periods.

Treatment processes

The size of sediment basins combined with the area to be treated will determine the level of treatment performance (Table 1). Ideally sediment basins should be sized to only capture coarse to medium sized sediments. These sediments typically have low concentrations of attached pollutants e.g. nutrients, pesticides and metals when compared to finer sediments. This means the sediment captured has low levels of contamination which makes its removal and disposal simpler.

Newly constructed sediment basin. Photo: QDAFF

Table 1 – Summary of sediment basin treatment processes

Pollutant Size / Type	Treatment Performance	Description of Sediment Basin Treatment Process
Coarse to medium sized pollutants (e.g. sediments)		Pollutants trapped by sedimentation (settling) processes in the sediment basin.
Fine particulates (e.g. fine sediments and particulate nutrients)		Very fine particles are not typically captured in sediment basins because the hydraulics of the pond does not allow a long enough settling period. If conditions allow fine pollutants to be trapped, these may retain or adsorb pollutants which are susceptible to release under conditions of low redox potential caused by high organic loading and stratification (low oxygen supply to sediments) or when scouring occurs under high flow conditions or following dry periods.
Dissolved pollutants (e.g. nutrients, chemicals and pesticides)		There may be some biological uptake of soluble nutrients predominantly by planktonic algae which can occur in the water column. However these pollutants are susceptible to being transported downstream during the next run-off event.

Use of sediment basins on farms to manage run-off

Sediment basins can be used as part of an overall farm drainage strategy to improve run-off water quality provided best practice farm management practices are implemented and a number of key design considerations are addressed. Planning treatment elements should also consider their position in the catchment and whether the location is suitable.

Sizing

Sediment basins are sized to capture a target sediment size (typically 125µm). The removal of smaller sized sediments should be left to vegetated treatment systems such as constructed wetlands. As a general rule of thumb the basin will need to be 0.5% of the contributing catchment.

More detailed equations can be used to more precisely calculate the required size of a sediment basin. This is done by matching the settling velocity of the target sediment size with a design flow, which is typically one year Average Recurrence Interval flow (ARI). Figure 1 is one equation that can be used to determine the size of a sediment basin. There are also other equations and methods that are used and engineers can help in that regard.

$$A = \frac{Q}{V_S}$$

where: A = surface area of the sediment basin (m^2)

Q = flow rate (m^3/sec)

V_S = sediment settling velocity (metres/sec)

Figure 1 – Equation to determine sediment pond sizing (from The Wetland Management Handbook available at www.wetlandinfo.ehp.qld.gov.au)

Site constraints

Sediment basins are not ideally suited to sites with:

- are steep sites (>4%)
- have shallow bedrock
- have high water tables
- have acid sulfate soils.

These site characteristics don't preclude the use of sediment basins, but they may require additional design considerations and have cost implications.

Flat catchments or multiple catchment areas can also pose a problem when trying to convey flows to a central sediment basin. A drainage network leading to a central point could assist in this instance.

Position and role in a run-off treatment train

The adoption of in-block best management practices and appropriate location within the drainage of the farm will protect the sediment basin from scour and excess sedimentation and will improve the overall water quality leaving the farm.

Sediment basins are typically used as a pre-treatment device for constructed wetlands, which can target finer sediments, nutrients and other pollutants (Figure 2).

When used in a treatment train, they can perform two key roles:

1. Remove coarse to medium sediments from run-off to protect downstream treatment systems such as constructed wetlands from being smothered by sediments. This allows them to target finer sediments, nutrients and other pollutants.
2. Control flows entering downstream treatment systems by diverting high flows away from the constructed wetlands, protecting them from scour and resuspension.

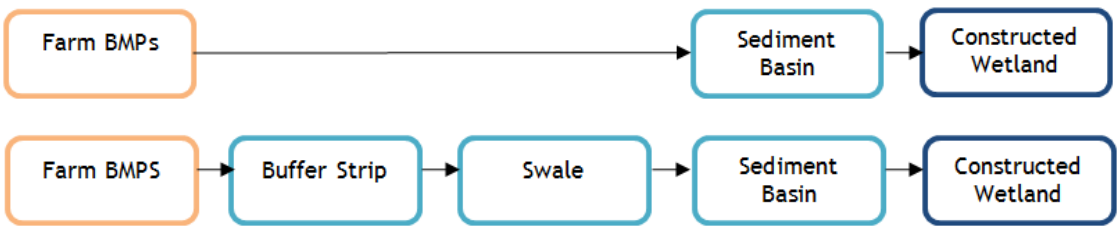


Figure 2 – Possible locations of sediment basins in farm run-off treatment trains

Design, construction and maintenance

Design requirements

Sediment basins should have the following design features:

Settling pond/storage area

Provision of adequate storage (i.e. depth) is required for settled sediment to prevent the need for frequent de-silting. A desirable frequency of basin de-silting is once every five years or when sediment accumulates to half the basin depth (see 'Maintenance' for additional detail on de-silting). This will depend on the size of the pond and the sediment loading. A compacted rock base can be useful when de-silting the basin to indicate the original depth and allow machinery access to the base of the pond.

Inlet and outlet structures

Run-off usually enters the sediment basin via a swale, drain or pipe. If a constructed wetland is established downstream, the outlet from the sediment basin should be designed so that only 'design flows' (typically the one year ARI) enter the constructed wetland. This outlet structure can be a pipe or weir and will need to be designed to accommodate the design flows for the constructed wetland.

High flow and overflow structures

High flow outlet structures should be designed to bypass 'above design flows' from the sediment basin around the downstream constructed wetland. These are often a spillway which discharges to a bypass channel. Site terrain may limit the use of bypass systems in some circumstances.

Specific design adaptations

Aggressive aquatic weeds can be a significant issue in tropical Queensland. A design response to manage the weed issue particular to this region is to avoid the inclusion of open water in sediment basins. Dry sediment basins and vegetated sediment basins are proposed as design adaptations. These design adaptations are described in the following sections.

Dry Sediment Basins

With the absence of a permanent pool, the performance of a dry sediment basin relies on the volume created by extended detention depth and its area. This detention time allows sediments to drop out of the water column before the system drains.

The available extended detention depth is reduced as sediment accumulates. Total depths of less than 1.5m restrict performance and sediment storage. To make sure that water can drain away, a 1.5m deep sediment basin requires at least that same vertical difference between the invert (bottom) of the upstream drain and the water level in the downstream constructed wetland system (Figure 3). Where a dry basin has no gravity outfall, the basin may need to be emptied by pump after run-off events.

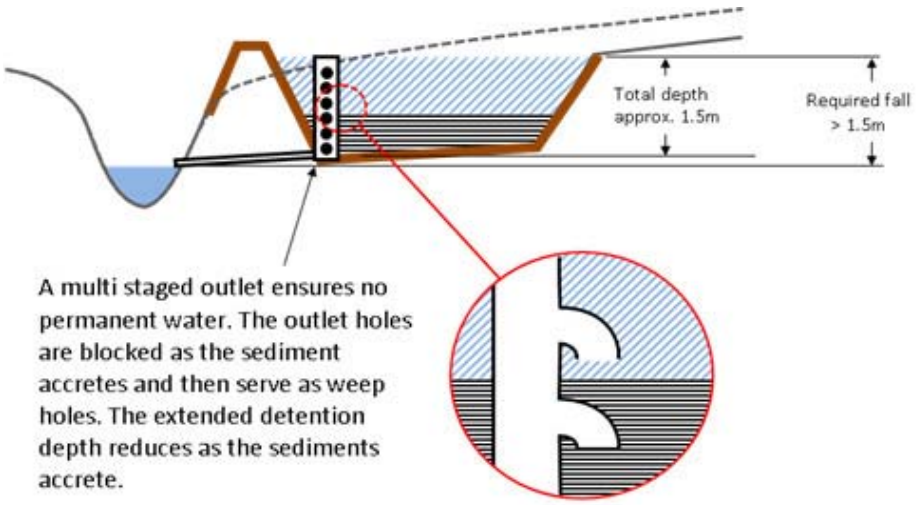


Figure 3 – Section of dry sediment basin showing outlet configuration

Vegetated Sediment Basins

Designing vegetated sediment basins ensures that the inundated areas are already occupied by design vegetation (typically emergent macrophytes e.g. reeds and sedges) and can therefore limit the growth of weeds.

Although this vegetated basin appears similar to a constructed wetland, there a number of key differences as summarised in Table 2. These differences are largely driven by the smaller size of the sediment basin which results in hydrologic impacts (such as high through-flow velocities), which are likely to limit the range of suitable macrophyte species which can be used in the sediment basin. These velocities are also likely to compromise the viability of biofilms and biological processes, and therefore they are not likely to attain the pollutant reduction performance of a constructed (treatment) wetland.

Table 2 – Comparison of vegetated sediment basin and constructed treatment wetlands

Design Features	Vegetated Sediment Basin	Constructed Treatment Wetland
Size relative to contributing catchment	0.5%	5-7%
Target pollutants	Coarse sediment removal	Fine and soluble pollutant removal
Key treatment processes	Sedimentation (settling) processes	Enhanced sedimentation and direct uptake of nutrients in vegetation and attached biofilms

The design of these vegetated sediment basins should incorporate:

- a first compartment, sized for capturing coarse particles which should be easily accessible for regular maintenance, and
- a deep marsh to maximise sediment storage volume and avoid open water.

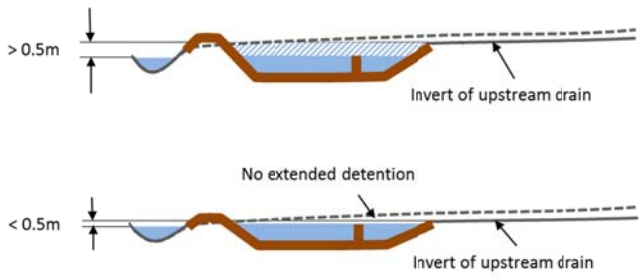


Figure 4 – Section of vegetated sediment basin highlighting fall is required to provide extended detention above the permanent water level.

Typical construction issues

Existing vegetation and approvals

Sediment basins should be located to avoid disturbing existing wetlands and native vegetation. Any disturbance to existing vegetation may trigger the requirement for a clearance approval.

Earthworks

Sediment basins require earthworks to create the excavated settling pond/storage area. The earthworks required for a vegetated sediment basin will be more complex than a dry sediment basin as it requires consideration of levels needed for plants to establish throughout. Also, earthworks within the vicinity of an area mapped as a wetland protection area may trigger an approval process.

Planting and establishment

Vegetated sediment basins will require new plant stock to enable the planting out of the majority of the sediment basin. Dry sediment basins will also require planting with a suitable native groundcover or grass. These plants should be sourced as soon as possible to ensure plants are available when needed to limit the time that bare soil is exposed.

Use local guidelines if they are available to assist with plant selection or contact your local Landcare or NRM group. Natural waterways, wetlands and riparian zones are a good reference from which to create a possible species template.

Topsoil should be stripped, stockpiled, and replaced as a growing media for the basin.

The establishment of the vegetation may require irrigation and weed management until it is fully established, which can take up to 2 years.

To improve the success of vegetation plantings allow time for establishment before the wet season. Planting in April/May means you can take advantage of available soil moisture and allow the plants to gain some height before inundation during the wet season. However, some irrigation may be required during the dry season.

During the early stages of vegetation establishment, water birds can be a nuisance by pulling out recently planted species. Interlocking planting systems, e.g. where several plants are grown together in a single container such as 'floral edges', can be used.

The water level may need to be manipulated in the early stages of vegetation growth and during prolonged wet seasons to maximise the chances of successful macrophyte establishment and to minimise the risk of plants being drowned. This can be achieved by closing off the connection into the sediment basin.

Cost implications/risk

Vegetation can be expensive, especially if the entire sediment basin requires planting. The risk of not achieving the desired design planting densities is weed colonisation and associated weed control costs.

Maintenance

Maintaining healthy vegetation is a key maintenance consideration to ensure the sediment basins are not colonised by weed species.

The most intensive period of maintenance is during the plant establishment period in the first 2 years when weed removal and replanting may be required to achieve the desired design densities of plants.

Typical maintenance of sediment basins will involve:

- Removing sediment when capacity is less than half the storage area and before the start of the wet season. Machinery and access will be required for de-silting the sediment basin. Removed sediments should be placed in a location where it can de-water away from drainage lines and natural waterways (ideally upstream of the sediment basin so flows can drain back into it). Once sediments are dried, they should be removed and can be used back in the blocks.
- Repairing any erosion, especially if it has created isolated pools in the batters.
- Removing blockages and repairing erosion at inlets and outlets.
- Irrigating the vegetation during dry periods.
- Removing weeds before they spread and/or set seed.

Sediment basins should be inspected every six months or after every major rain event.

These factsheets were developed by the Queensland Department of Agriculture, Fisheries and Forestry (QDAFF), Healthy Waterways and E2DesignLab with funding from the Queensland Wetlands Program.

The Queensland Wetlands Program supports projects and activities that result in long-term benefits to the sustainable management, wise use and protection of wetlands in Queensland. The tools developed by the Program help wetlands landholders, managers and decision makers in government and industry. The Program is a joint initiative of the Australian and Queensland governments.

Contact wetlands@ehp.qld.gov.au
or visit www.wetlandinfo.ehp.qld.gov.au

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Further information

This fact sheet is part of a series on run-off treatment systems, as listed below. The Wetland Management Handbook provides more detail on treatment structures and general farm management to improve water quality leaving farms.

These resources and other wetland management tools and guides are available at

http://wetlandinfo.ehp.qld.gov.au/wetlands/management/wetland-management/

Number	Publication Title
Fact sheet 1	Farm run-off treatment systems—toolkit
Fact sheet 2	Buffer strips
Fact sheet 3	Vegetated swales and drains
Fact sheet 4	Sediment basins
Fact sheet 5	Constructed (treatment) wetlands

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